FINAL TECHNICAL REPORT

Research:

Sea ice parameters in the north and south polar regions are important components of the global climate system. Current air-sea-ice models do not take into account oscillatory behavior in the ice covers other than for the seasonal cycle, since the relative importance of such oscillations is not known. An analysis of oscillatory behavior then becomes important from the standpoints of determining the significance of the various oscillatory components and perhaps discovery of some new aspects of the air-sea-ice interaction processes. One of these components, the El Niño-Southern Oscillation (ENSO) is known to be associated with weather changes on a global scale. Indeed, its spectral components have also been observed in the sea ice distribution in both hemispheres.

Variations in the Arctic sea ice concentration during 1978-1987 have been studied utilizing the data obtained from the scanning multichannel microwave radiometer (SMMR) on board the Nimbus 7 satellite. The mean, linear trend, and seasonal cycle (the latter composed of five harmonics of the annual cycle) from the time series for each pixel of gridded SMMR ice concentration data in the Arctic have been determined, then removed, using multiple linear regression. It is found that the 9-year trends are most positive in the Beaufort and East Greenland Seas, whereas the most negative areas are in the the Barents Sea and the sea ice surrounding Svalbard; this is similar to trend patterns in the lengths of the sea ice season reported earlier by Parkinson. In the residual data the standard deviation ranges from 12% to 16% in the central Arctic basin, considerably above the estimated wintertime ice concentration accuracies of 5% in that region; this is in part due to fluctuations in the ice concentration rather than noise. Two approaches, multitaper spectral analysis and singular value decomposition, were taken in order to identify some of the oscillatory components and to study the temporal and spatial variations of the sea ice. Various spectra were found, besides the predominant annual cycle and its first three harmonics. Many of these oscillations are found to be related with quasi-biennial and quadrennial ENSO Components and, in some area, with the tidal motion as well. Similar studies have been carried out for the global sea surface temperature and the Arctic sea ice temperature.

More recently, Empirical Mode Decomposition methods have been applied to the Arctic sea ice concentration data and the global sea surface temperature data in order to separate some of the ENSO components from the time series at selected pixel. A successful separation of the component will allow a further study of the complicated features of these components.

Education:

Education effort for my JOVE program can be summarized in two aspects: student support and curriculum development. Over the course of my JOVE program, I have supervised three graduate students and three undergraduate students. In order to have students involved with NASA research, I helped one of my graduate students submit

a proposal to NASA Global Change Fellowship Program in March of 1994. In 1995, I sent another graduate student to attend 1995 Fall Meeting of American Geophysical Union in San Francisco. In the summer of 1995, I sent one of my undergraduate research assistant to NASA Goddard Space Flight Center (GSFC) for an on-site research. As a result, a poster paper, first authored by the student was presented at the Tenth National Conference on Undergraduate Research at the University of North Carolina at Asheville in April of 1996. In the summer of 1996, I recommended another undergraduate research assistant of mine to the Summer Institute on Atmospheric and Hydrospheric Sciences at GSFC. The result of the research project at the summer institute has been published in a refereed Journal article.* Among the three undergraduate students, two of them have moved on to attend graduate school in an area related to JOVE project.

As for the curriculum development, a new course, Mathematical Modeling, was introduced into the Math department curriculum in the Spring semester of 1994. In order to create interaction between students and NASA scientists a main part of the modeling course is devoted to the climate modeling using a text book by a senior scientist at NASA GSFC. Also, programs such as Porject Mathematics, Polynomials, Sine and Cosine on video tapes copied from the Teacher's Resourse Center at NASA have been incorporated into Calculus courses at University of Vermont.

Outreach:

I have done two workshops and given two presentations during the period of my JOVE program. The first workshop was conducted in the 1994 Summer Institute of Mathematics and Technology at University of Vermont. Five presentations were given during the one-week workshop, which cover an introduction of my JOVE research project, computer graphing and the Internet. The second workshop is a part of the VT EPSCoR outreach project in 1996. Five lectures were given to a team consists of two students and one teacher from St. Johnsbury Academy, a high school sellected among schools in Vermont. The project were then brought back to the St. Johnsbury Academy so that other students and teachers can benefit from it.

The first presentation was given at Junior Conference sponsored by the University of Vermont in May of 1996 and the second was in the Science Fair at Central Elementary School in South Burlington, VT in April of 1996. Materials of NASA's Education Programs were handed out during the second presentation.

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* Gloersen, P, and **A. Mernicky**, Oscillatory behavior in Antarctic sea ice concentrations, AGU Antarctic Research Series: Antarctic Sea Ice Physical Properties and Processes, M.O. Jeffries, ed., accepted February 25, 1997.

Summary of outcomes for my JOVE program

JUN YU
Dept. of Mathematics and Statistics
University of Vermont
Burlington, VT 05405

1.) RESEARCH:
   One refereed Journal article published
   One other article submitted
   Four oral and poster papers presented
   Two proposals submitted

2.) EDUCATION:
   Six student research assistants associated with JOVE project
   One new course in modeling created

3.) OUTREACH:
   Two workshops given to teachers and/or students
   Two presentations given to teachers and/or students

Gloersen, P., **Yu, J.**, and Mollo-Christensen, E. (1996). Oscillatory Behavior in Arctic Sea Ice Concentrations from the Nimbus 7 SMMR. J. Geophys. Res. *vol.* 101, No. C3, *pp.* 6641-6650.

Yu, J. and Gloersen, P. (1995). Principal Component Analysis of the Arctic Sea Ice Concentrations from the Nimbus 7 SMMR. Submitted to J. Geophys. Res.

Gloersen, P., Mollo-Christensen, E., and **Yu, J.** (1993). Oscillatory Behavior in Arctic Sea Ice Concentrations. Invited Paper. Presented at the 1993 Fall Meeting of American Geophysical Union, San Francisco, California, December, 1993.

Yu, J. and Gloersen, P. (1993). Singular Value Decomposition of the Arctic Sea Ice Concentrations. Poster Paper. Presented at the 1993 Fall Meeting of American Geophysical Union, San Francisco, California, December, 1993.

Gloersen, P. and **Yu, J.** (1995). Spatial Distribution of the Quasibiennial & Quasi-Quadrennial ENSO Components in Global SSTs. Oral presentation. Presented at the XXI General Assembly of the International Association for the Physical Sciences of the Oceans, Honolulu, Hawaii, August, 1995

Brosseau, J., **Yu, J.** and Gloersen, P. (1996). Variations in the Sea Ice Temperatures in the North Polar Region. Poster presentation. Presented at the Tenth National Conference on Undergraduate Research, University of North Carolina at Asheville, April 18-20, 1996

Proposal #1 was submitted to NASA Global Change Fellowship Program in March 1994.

Proposal #2 was submitted to NASA EPSCoR Program in September 1995.

Six student research assistants: Carolyn P. Wagner, Wen Ding, Alena Mernicky, Jie Wu, James Brosseau and Chris Luczynski

New course, Mathematical Modeling, was introduced into curriculum January 1994.

Workshop #1 is the 1994 Summer Institute at University of Vermont.

Workshop #2 is the EPSCoR outreach project in 1996.

Presentation #1: Junior Conference Seminar in May of 1996.

Presentation #2 was given in the Science Fair at Central Elementory School in South Burlington, VT in April of 1996.